PALAU: DIVERSITY AND STATUS OF THE NATIVE VEGETATION OF A UNIQUE PACIFIC ISLAND ECOSYSTEM

Joan E. Canfield
Department of Botany
University of Hawaii at Manoa
Honolulu, Hawaii 96822

INTRODUCTION

The Palau island group lies at the western border of both the Caroline Islands and Micronesia in the western Pacific From 1977 to 1979, I was engaged as botanist in Palau by the Peace Corps/Smithsonian Environmental Program. I worked at the Office of the Chief Conservationist of the Trust Territory of the Pacific Islands. My collecting trips throughout the district of Palau enable me to provide this overview of the vegetation types of Palau, and a few words about the uniqueness of that small corner of the Pacific.

SETTING

The Palau island group is located roughly 500 miles east of the Philippines, north of New Guinea, and southwest of Guam (Fig. 1). It is made up of over 300 individual islands, most of them within a huge barrier reef that stretches 70 by 20 miles. The total land area of Palau District is 188 square miles, the size of Lāna'i and Kaho'olawe put together. Palau covers just one-half of the land area of Hawaii Volcanoes National Park.

Palau is occupied by some 15,000 people, whose ancestors migrated on many successive occasions from the Philippines, Indonesia, and Melanesia, beginning about 1500 B.C. The island group has been subjected to Spanish, German, Japanese, and American administration over the past 100 years. The 37-year long U. S.-administered U. N. Trusteeship ended January 1, 1981. With the creation of the Republic of Belau, Palau has become an independent nation.

Palau is barely 7° north of the Equator. Its climate is hot and damp: average temperature throughout the year is 80°F and the relative humidity 80%, with an annual rainfall of about 150 inches. Northeast trade winds prevail throughout the winter months, and typhoons are infrequent.

Palau's flora is richer than that of any other district of Micronesia, in part because of its greater proximity to Asia which has increased the probability of dispersal of taxa from Asia to Palau. At the same time, the isolation of the 330 islands of Palau from surrounding island groups has helped give rise to a large number of endemic species. In addition, a wide variety of substrates and habitats has made it possible for more immigrant taxa to persist on Palau.

The diversity of landforms and substrates in Palau is especially remarkable for such a small Pacific island group. The largest island in Palau, Babeldaob, is of ancient volcanic origin, today reaching only a moderate elevation of 240 m (790 ft). Nearly all of the other islands of Palau are of coral limestone rather than of volcanic origin. Koror Island, the district center, is both volcanic and limestone. In Palau, some ancient reefs have been uplifted into raised limestone islands, up to 220 m (720 ft) in elevation, as well as into classic low coral atolls.

This paper will briefly describe eight very broad vegetation associations characteristic of the substrates just mentioned. These vegetation types follow those of Fosberg (1960).

Strand

The strand association should appear familiar to Hawaiian residents. Most strand plants are easily dispersed by ocean currents, so that most of Hawai'i's strand species also grow in Palau. Strand communities are found on the atolls of Palau, the low coral islands, and on the east coast of the big volcanic island, Babeldaob, inside the fringing reef. Strand species common to both Hawai'i and Palau include kou (Cordia subcordata Lam.), the tree heliotrope (Messerschmidia argentea (L. f.) Johnston), and naupaka-kahakai (Scaevola taccada (Gaertn.) Roxb.).

The strand communities of Palau do not appear to be as extensive, diverse, or fragile as those of Hawai'i, perhaps because the protected coastline inside Palau's barrier reef allows a richer forest community to take over much of the strand habitat.

Low Coral Island Forest

The influence of man is immediately obvious in this vegetation type, many of the species being economically valuable ones. In Palau, as in Hawai'i, Casuarina, coconut (Cocos nucifera L.), hau (Hibiscus tiliaceus L.), and Pandanus appear in low coral island vegetation, as well as breadfruit (Artocarpus), arrowroot (Tacca leontopetaloides (L.) O. Ktze.), and others.

Mangrove

There are half a dozen major mangrove species in Palau, forming a broad zone along the west coast of Babeldaob, up the river channels of that island, at the margin of a few low coral islands, and bordering the intriguing marine lakes found in some raised limestone islands (these marine lakes are landlocked except for underwater channels linking them to the lagoon waters).

The aerial roots of mangroves enable the trees to absorb oxygen which is lacking in the thick mud washed down to the mangrove swamp from the island interior. Mangrove species are easily identified by aerial root characteristics. Also, mangroves usually are found in distinct zones mauka from the lagoon. Nearest the sea grow Sonneratia alba J. E. Sm. and two species of Rhizophora (R. apiculata Bl. and R. mucronata Lam.). Sonneratia's aerial roots are slender and erect, while Rhizophora has interlocking proproots which grow from high on the trunk. Further inland, in less saline water, is Bruguiera gymnorhiza (L.) Lam., with looped aerial roots. The Nypa palm (Nypa fruticans Wurmb.) is another member of the mangrove formation; it is easily recognized by its distinctive odor, reminiscent of dead crocodile. In fact, crocodiles are all too common along Palau's mangrove channels.

Ecologically mangrooves are very important, trapping the rich sediment runoff from the volcanic islands. Logging of these mangrove forests could lead to serious siltation at the reef edge, which would not only waste valuable fertile soil but also kill reef organisms.

Coastal Plain

The coastal plain vegetation type shows perhaps the greatest influence of man. The rich agricultural land, gentle topography, and ready access to the lagoon waters have made the coastal area the prime site of Palauan habitation. What once were dense forests have been cut over and replaced with tapioca and sweet potato fields, taro swamps, and agriforests, made up of a combination of native and introduced species of economic value. Most of the introduced plants of the coastal plain are used throughout Polynesia, and should be familiar: coconut, mango (Mangifera indica L.), guava (Psidium guajava L.), various citrus species, over 10 varieties of banana (Musa spp.), papaya (Carica papaya L.), and useful ornamentals such as ti (Cordyline terminalis (L.) Kunth), hibiscus, and many more.

While the utilization of the coastal lowland has probably restricted the distribution of some native species, the managed agriforests seem to make up a fairly well-balanced ecosystem.

Lower Primary Forest

Little remains of the primary forest of the lower slopes of Palau's volcanic islands. However, reasonably mature forest can still be found on the west coast of Babeldaob. These areas are prime examples of tropical island jungle: the massive trees are hung with thick lianas, their trunks carpeted with mosses, branches trailing great curtains of ferns and orchids. The community structure of these forests has not been studied, but they appear to be quite rich in numbers of species.

Secondary Forest Slopes

Here the original forest was once cleared for agricultural use. Common crops are coconut, dryland taro (*Colocasia esculenta* (L.) Schott.), and tapioca (*Manihot esculenta* Crantz). Much of this farmland has been abandoned, however. Secondary succession has followed, through grass and scrubland to a fairly dense secondary forest. The Palau tree fern (*Cyathea lunulata* (Forst. f.) Copel.) is a common dominant, as is *Semecarpus venenosus* Volk., an especially toxic relative of poison ivy. Here, too, is *Ixora casei* Hance ex Walp., found as an ornamental in Hawai'i.

Savanna

The rolling hilltops of most volcanic islands in Palau are covered with a savanna vegetation of scattered shrubs, grasses, and uluhe (*Dicranopteris linearis* (Burm.) Underwood), rather than forest. These upland savannas may be natural, lacking forest because of the nutrient-poor clay soil, which the Japanese were able to mine for bauxite. It is fairly certain, however, that the savannas are now much more extensive because of the recurrence of fire. The Palauans traditionally set fire to these hills to clear the land for farming. Today fires are set to clear paths for pigeon and fruit bat hunters, or else just for sport.

Recurrent fire has changed the savanna substrate and vegetation. Topsoil washes away following fire, and regeneration of fire-resistant plants is favored. As in Hawai'i, the fire-favored grasses and uluhe catch fire easily themselves. Subsequent burning then destroys a larger savanna area, burning on into the forested ravines. Eventually, the savanna slopes are reduced to eroded clay canyons, supporting little vegetation and of no use as farm or pasture land.

While the end result of savannas burned repeatedly is economically useless land, the less severely burned savanna vegetation is quite appealing. The rolling hills are covered with clubmoss (*Lycopodium cernuum* L.), dotted with shrubs, ground orchids (*Spathoglottis*), and occasional *Pandanus* trees, a welcome relief from the thick tropical forest. Succession in these areas is especially intriguing, with the great number of native savanna shrub species.

Raised Limestone Islands

The islands of southern Palau typically are extremely steep, up to 220 m (720 ft) in elevation, and undercut by a combination of wave action and the activity of marine invertebrates. The loose limestone substrate is quite dissected and eroded by rain water, and treacherous for human limbs. Virtually no plant ecological work has been carried out on these limestone islands. The vegetation is quite distinct from forests on volcanic substrates, and can be divided into four basic types: cliff, ridgetop, slope, and depressions and marine lake margins.

The cliffs support a community similar to the strand or back of strand vegetation in Palau: Casuarina and Pandanus are common, as is Dracaena. An endemic member of the Rubiaceae, Bikkia palauensis Val., is probably the showiest cliffdweller.

The ridgetop limestone island vegetation was formerly dominated by several native palm species, two of them endemic (Gulubia palauensis (Becc.) Moore & Fosb. and Ptychosperma palauensis (Kaneh.) Moore & Fosb.). Unfortunately, the introduced Sulphur-crested Cockatoo (Cacatua galerita (Latham) and Eclectus Parrot (Eclectus roratus (P. L. S. Müller) are killing these palms by eating the terminal buds. The native palms have been declared endangered and are already very rare in the upper canopy level of all but the most isolated limestone islands.

The slopes of the limestone islands typically lack a humus layer, yet they are extremely densely vegetated. Common members of this diverse assemblage are Elaeocarpus, Intsia bijuga (Colebr.) O. Ktze., numerous ferns, and endemic orchids.

Depressions and marine lake margins host yet another vegetation type, also rich in ferns and herbaceous species.

The limestone islands are rugged enough to discourage most plant collectors. Doubtless, there are endemic species yet to be discovered on these hundreds of islands.

In addition to the steep limestone islands, there are two larger but less precipitous raised limestone islands in Palau. Peleliu and Angaur were the sites of phosphate mining and heavy wartime activity, which together decimated much of the original vegetation. The scrub forest that has grown up out of the bombed and bulldozed rubble of the mid-1940's is distinctive. Oddly enough, it supports at least one apparently endemic species, Maesa canfieldiae Fosb. & Sachet (Myrsinaceae). This plant may yet prove to be a weedy wartime introduction. Much of the flora of Peleliu and Angaur is weedy; Hawaiians would recognize Ipomoea species, Lantana, and Operculina among the nastier pests there.

FLORA OF PALAU

Some preliminary statistics on the flora of Palau are provided in Table 1. These numbers are highly preliminary in nature, based on a checklist that I helped F. R. Fosberg of the Smithsonian Institution to compile (Fosberg et al. 1980). As Table 1 indicates, members of 143 families of higher plants have been recorded from Palau. Families with the greatest representation of native taxa in the Palau flora are the orchid and sedge families and the Rubiaceae. Altogether 1258 taxa, including varieties, have been found on Palau's 188 square miles. A full two-thirds of those taxa are native. The native plants represent over 400 genera.

Palau boasts 67 endemic species, and 10 endemic varieties (Table 2). This means that over 9% of the taxa native to Palau are endemic. That percentage pales by comparison with the 97.5% level of endemism given for Hawai'i by St. John (1973). However, considering the size of Palau in relation to Hawai'i--just 3% of Hawai'i's total land area--and Palau's proximity to a continental landmass, the figure for Palauan endemics is quite respectable.

The importance of substrate and habitat diversity to the floral richness of Palau has already been noted. New niches must have been available to immigrant plants on this unusual combination of low and uplifted limestone and basalt. This diversity has permitted the differentiation and survival of Palauan endemics.

HUMAN DISTURBANCE

Several disturbance factors that have taken a toll on Palau's native vegetation have already been mentioned. These include the historical burning of uplands, extensive cultivation of lowlands, and the recent influx of weedy introductions, especially since World War II.

As in Hawai'i, large-scale development proposals threaten the native flora and fauna of Palau. The most disturbing of these is an oil supertanker port proposal, which has been defeated for the present. Hopefully, the superport concept is already outmoded. Imagine the effect of an oil spill on Palau's 100-mile long reef! The incredible diversity of marine organisms in Palau's lagoons is unfortunately beyond the scope of this paper.

PROGNOSIS

Just as in Hawai'i, comparatively little progress has been made toward setting aside natural areas for preservation in Palau. The Seventy Islands Nature Reserve is one exception. A built-in advantage for much of the native vegetation of Palau is its inaccessibility and inhospitality to the human species. The craggy, chigger-infested, poison tree-filled high limestone islands are destined to remain fairly pristine.

A final encouraging word on Palau is that, again as in Hawai'i, the native people are beginning to revive their own traditional conservation ethic and affirm the value of their prime native treasure: a unique island ecosystem worthy of preservation, both for their own future and for that of all the earth's inhabitants.

LITERATURE CITED

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TABLE 1. Vascular flora of Palau.

	Native		Exotic		Native & Exotic		Total
	#	%	#	%	#	%	
Families	53	37%	26	18%	64	45%	143
Genera	54	8%	230	35%	369	57%	653
Species	797	66%	418	34%	--	--	1215
Vars. & Subspp.	33	77%	10	23%	--	--	43
TOTAL Taxa	830	66%	428	34%	--	--	1258

TABLE 2. Endemic plants of Palau.

	Native Taxa	
	#	%
Species	67	8%
Varieties	10	30%
TOTAL Taxa	77	9%

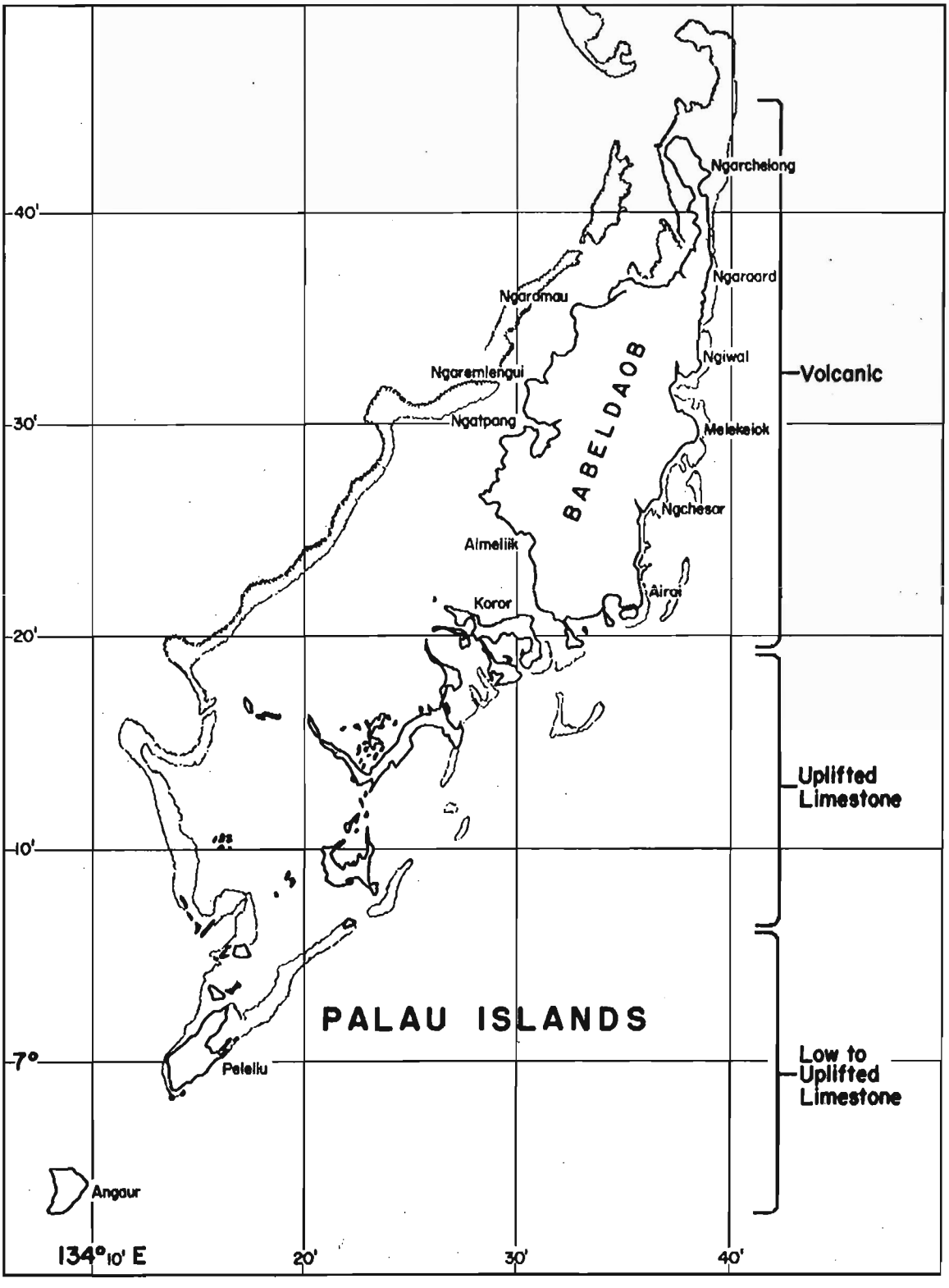

FIGURE 1. Map of the Palau Island group.